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Effect of Nano-DAP on yield, nutrient uptake and nutrient use efficiency by rice under Bastar plateau

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Abstract
A field experiment has been conducted during *kharif* 2021 at Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur, Chhattisgarh on effect of Nano-DAP on nutrient use efficiency and yield of rice with six treatments and four replications *viz.* T_1 RDF(100% NPK), T_2 (25% P+ 100% N, K + root dipping, and one foliar spray of Nano DAP at 20-25 DAT), T_3 (25% P+ 100% N, K + root dipping with nano and two foliar sprays of Nano DAP at 20-25 DAT and 45-50 DAT), T_4 (50% P+ 100% N, K + root dipping, and one foliar spray of Nano DAP one foliar spray of Nano DAP at 20-25 DAT), T_5 (50%P+ 100% N, K +root dipping, and two foliar sprays of Nano DAP at 20-25 DAT and 45-50 DAT) and T_6 (Control). The soil was sandy loam in texture with slightly acidic in nature and low in organic carbon status. The available nitrogen was low while phosphorus and potassium were medium. T_5 (50% P+100% NK+root dipping and two foliar spray of nano-DAP at 20-25 DAT and 45-50 DAT) was found the most significant on performance over other treatments except T_1 on yield. The agronomic use efficiencies for N, P and K under T_5 were 31, 103.4 and 77.6 kg grain/ kg nutrient applied which were better among other treatments. Similarly, nutrient use and production efficiencies for N, P and K under T_5 were significantly higher over rest of the treatments. Therefore, we may suggest for 50% P+100%NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50 DAT for better realization of applied nutrients in terms of nutrient use efficiencies and yield responses.

Keywords: Nano-DAP, nutrient, rice, Bastar, plateau

Introduction
Rice is an important crop as the slogan 'Rice is Life' is more appropriate for India as this crop plays a vital role in our National food security and is a means of livelihood for millions of rural household, grown in about 43.79 mha of land area in the country with the productivity of 2.65 ton/ha. Recent study suggests excessive usage of conventional chemical fertilizers cause accumulation of toxic by-components in soil which results in deterioration of soil ecological environment by heavy metals, nitrate and other harmful components. Nano scale fertilizers have the potential to act as a catalyst for plant growth and can enhance the exchange of plant gases and root efficiency. Furthermore, due to the slowness and control of nutrient release, nano fertilizers are able to increase the availability of nutrients in the root zone (De Rose, *et al.*, 2010) [1]. Newly developed Nano-fertilizers by using nanotechnology are smaller in size, with large surface area leading to increase in absorption capacity and controlled-release kinetics to targeted sites. (Rameshaiah *et al.*, 2015) [2]. The combine application of traditional and nanoparticle mineral fertilizers may create a continuous nutritional balance for the different growth stages of the rice plant, may help in reduction in the use of chemical fertilizers and the creation of a better environment for nutrient absorption in the plant, which is what the current study intends to evaluate the method of nano-DAP with the aim of improving nutrient use efficiencies and yield of rice.

Materials and Methods
A field experiment was conducted during *Kharif* Season 2021 at AICRP Dryland Agriculture research field of S.G. College of Agriculture & Research Station (Kumhrawand) Jagdalpur, Chhattisgarh. The experiment was laid out in Randomized Complete Block Design with six treatments and four replications. The treatment comprised of T1: RDF(100% NPK), T2: (25% P+ 100% N, K + root dipping and one foliar spray of Nano DAP at 20-25 DAT), T3: (25%P+ 100% N, K + root dipping and two foliar sprays of Nano DAP at 20-25 DAT and 45-50 DAT), T4: (50% P+ 100% N, K + root dipping and one foliar spray of Nano DAP at 20-25 DAT), T5: (50%P+ 100% N, K + root dipping and two foliar sprays of Nano DAP at 20-25

DAT and 45-50 DAT), T6: (Control). Root dipping with Nano-DAP (5 ml/lit) for 15 minutes and foliar spray of Nano-DAP (2 ml/lit). The recommended fertilizer N, P_2O_5 and K_2O was 100:80:60 kg/ha and spacing was 20 cm x 20 cm. NPK uptake by grain and straw were calculated by multiplying their respective nutrient contents with yields. The agronomic efficiency as the economic production found per unit of nutrient applied was calculated by- AE (kg $kg^{-1)}$ = (Gf–Gu/Na), where Gf is the grain yield of the fertilized treatments (kg), Gu is the grain yield of the unfertilized treatments (kg) and Na is the amount of nutrients applied in treatment (kg). Apparent recovery efficiency as the quantity of nutrient uptake per unit of nutrient applied calculated by- ARE (%) = (Nf−Nu/Na) X100, Where Nf is the nutrient uptake (grain plus straw) by plant with fertilized plot (kg), Nu is the nutrient uptake (grain plus straw) by plant with unfertilized plot (kg) and Na is the amount of nutrient applied (kg).

Production efficiency (kg grain/ kg nutrient uptake) was calculated as PE = (yield in treated plot – yield in control)/ (Nutrient uptake in treated plot – nutrient uptake in control).

Result and Discussion

Yield

The higher grain yield (5518 kg ha^{-1}) was recorded under T_5 (50%P+100%NK+root dipping and two foliar spray of nano-DAP at 20-25 DAT and 45-50DAT), which was statistically at par With T_1 and the lowest (2415 kg ha^{-1}) was obtained under control (T_6) (Table 1). More or less, similar observations were drawn by Rathnayaka *et al.* (2018) [3] and Jassim *et al* (2019) [4] and concluded that the highest yield was obtained in the treatment where 100% Nano N fertilizer was added.

The straw yield of all treatment increased significantly with levels of spray of Nano-DAP over control. The highest straw yield 7315 kg ha^{-1} was recorded under T_5 (50%P+100% NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50 DAT) which was statistically at par with T_1 (RDF) and the lowest obtained (2916 kg ha^{-1}) under control (T_6) (Table 1). Similar findings were reported by Tarafdar *et al*. (2014) [5] and Kumar *et al*. (2020) [6] that it gained higher yield in rice via applying nano fertilizer. That was in agreement with the findings of many researchers that nano-fertilizer application increased crop yield by 15% - 20%.

Nutrient uptake

N, P and K uptake by grain (71.2, 16.0, 19.9 kg/ha, respectively), straw (43.2, 11.0, 98.0 kg/ha, respectively) and total (114.3, 27.0, 117.9 kg/ha, respectively) were significantly higher under treatments T_5 (50%P+100% NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50DAT) which was at par with T_1 (RDF 100%) (Table2). The nutrient uptake of rice was found to be increased with the foliar application of nano urea which might be due to nano fertilizer have large surface area and particle size less than the pore size of root and leaves of the plant which can increase their penetration into the plant from applied surface and improve nutrient uptake. These results were in close agreement with the findings of Laheri *et al.* (2021) [7] and Patil *et al.* (2020) [8] and concluded that nitrogen, phosphorus and potassium content in rice grain and straw; and total uptake directly relates to better productivity of the crop.

Nutrient use efficiency

The highest agronomic use efficiency for N (AE_N) of 31.0 kg kg^{-1} recorded with T_5 (50% P+100% NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50DAT) followed by T_1 (RDF 100% NPK). The agronomic use efficiency for P (AE_P) was recorded in the range of 50.3 to 127.5 kg kg^{-1} among different treatments. The highest AE_P of 127.3 kg kg^{-1} recorded with treatment 3 and lowest 50.3 kg kg^{-1} with treatment 1 (RDF 100% NPK). The maximum agronomic use efficiency for K (AE_K) (77 kg kg^{-1}) observed in treatment 5(50% P+100% NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50 DAT) followed by $treatment_1$ (RDF 100%) (Table 3).

The highest apparent nitrogen use efficiency (NE_N) of 77.6 recorded with T5 (50% P+100% NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50DAT) followed by T1 (RDF 100%). The highest NE_P of 127.3kg kg^{-1} recorded with treatment 3 and lowest 50.3kg kg^{-1} with treatment1 (RDF 100% NPK). Apparent pottasium use efficiency (NE_K) recorded in the range from 88.9 to 180.7 kg kg^{-1} with mean value of 148.3 kg kg^{-1}. The maximum NE_K (180.7 kg kg^{-1}) observed in treatment 5 followed by treatment 1 (177.1 kg kg^{-1}).

The production efficiency for N (PE_N) (kg grain per kg nutrient absorbed) ranged from 44.2 to 47.6 with the mean value of 45.8. The highest PE_N (kg grain per kg nutrient absorbed) of 47.6 observed under treatment 2 followed by treatment 4 (47.1 kg kg^{-1}). Production efficiency of phosphorus (PE_P) (kg grain per kg nutrient absorbed) recorded in the range of 172.6 to 197.4 kg kg^{-1} in different treatments. The highest PE_P of 197.4 kg kg^{-1} observed with treatment 2 followed by T3 with 192.9 kg kg^{-1}. Production efficiency of potassium (PE_K) (kg grain per kg nutrient absorbed) ranged from 42.6 to 47.6 kg kg^{-1} with mean value of 46.2 kg kg^{-1}. The maximum PE_K 47.6 kg kg^{-1} observed in treatment 4 (50% P+100% NK+root dipping and one foliar spray of Nano-DAP at 20-25 DAT) followed by treatment 2 (45.9 kg kg^{-1}). Similarly Mahanta *et al*. (2019) [9] and Quereshi *et al*. (2019) [10] concluded that Nano structured formulation might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer resources.

Table 1: Effect of spray of Nano-DAP on grain and straw yield of rice

Treatment		Grain Yield (kg/ha)	Straw Yield (kg/ha)
T1:	RDF 100% NPK	5433	7230
T2:	25%P+100%NK+root dipping and one foliar spray of nano-DAP at 20-25 DAT	4045	5184
T3:	25%P+100%NK+root dipping and two foliar spray of nano-DAP at 20-25 DAT and 45-50DAT	4327	5559
T4:	50%P+100%NK+root dipping and one foliar spray of nano-DAP at 20-25 DAT	5136	6336
T5:	50%P+100%NK+root dipping and two foliar spray of nano-DAP at 20-25 DAT and 45-50DAT	5518	7315
T6:	Control	2415	2916
	CD (5%)	275	367
	CV (%)	12.84	14.36

Table 2: NPK uptake by grain and straw of rice as influenced by Nano-DAP

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T1	70.1	41.9	112.0	15.2	10.1	25.3	19.6	96.9	116.4
T2	51.0	27.5	78.4	10.5	6.7	17.3	13.8	67.4	81.1
T3	55.0	30.6	85.5	11.7	7.2	18.9	15.1	72.8	88.0
T4	65.2	36.7	102.0	13.9	8.9	22.7	18.5	84.3	102.8
T5	71.2	43.2	114.3	16.0	11.0	27.0	19.9	98.0	117.9
T6	29.9	14.3	44.2	5.8	3.2	9.0	8.0	37.6	45.6
CD (5%)	4.35	3.42	7.84	2.64	2.08	4.55	2.46	6.82	9.35
CV (%)	11.24	9.64	10.88	8.32	12.41	11.48	9.26	14.81	13.92

T_1 (RDF(100% NPK), T_2 (25% P+ 100% N, K + root dipping, and one foliar spray of Nano DAP at 20-25 DAT), T_3 (25% P+ 100% N, K + root dipping with nano and two foliar sprays of Nano DAP at 20-25 DAT and 45-50 DAT), T_4 (50% P+ 100% N, K + root dipping, and one foliar spray of Nano DAP one foliar spray of Nano DAP at 20-25 DAT), T_5 (50%P+ 100% N, K +root dipping, and two foliar sprays of Nano DAP at 20-25 DAT and 45-50 DAT) and T_6 (Control).

Table 3: Effect of spray of Nano-DAP on nutrient use efficiencies

Treatment	Agronomic use eff. (kg grain/kg nutrient applied)			Apparent Nutrient use efficiency (%)			Production efficiency (kg grain per kg nutrient absorbed)		
	N	P	K	N	P	K	N	P	K
T1: RDF 100% NPK	30.2	50.3	75.5	67.8	27.2	177.1	44.5	184.8	42.6
T2: 25% P+100% NK+root dipping and one foliar spray of nano-DAP at 20-25 DAT	16.3	108.7	40.8	34.2	55.0	88.9	47.6	197.4	45.9
T3: 25% P+100% NK+root dipping and two foliar spray of nano-DAP at 20-25 DAT and 45-50 DAT	19.1	127.5	47.8	41.3	66.1	105.9	46.3	192.9	45.1
T4: 50%P+100%NK+root dipping and one foliar spray of nano-DAP at 20-25 DAT	27.2	90.7	68.0	57.8	45.8	142.9	47.1	198.1	47.6
T5: 50% P+100% NK+root dipping and two foliar spray of nano-DAP at 20-25 DAT and 45-50 DAT	31.0	103.4	77.6	70.1	59.9	180.7	44.2	172.6	42.9
T6: Control	-	-	-	-	-	-	-	-	-

Conclusion

Treatment 5 (50%P+100%NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50DAT) was found the most significant on performance over other treatments except T1 on yield and attributing characters, leaf area index and chlorophyll content. The agronomic use efficiencies for N, P and K under T5 were 31, 103.4 and 77.6 kg grain/ kg nutrient applied which were better among other treatments. Similarly, nutrient use and production efficiencies for N, P and K under T5 were significantly higher over rest of the treatments. Therefore, we may suggest for 50% P+100% NK+root dipping and two foliar spray of Nano-DAP at 20-25 DAT and 45-50DAT for better realization of applied nutrients in terms of nutrient use efficiencies and yield responses.

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